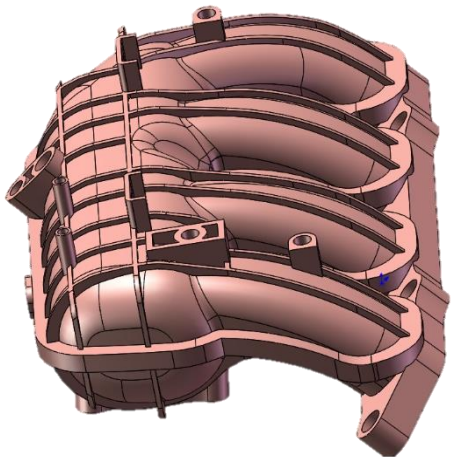
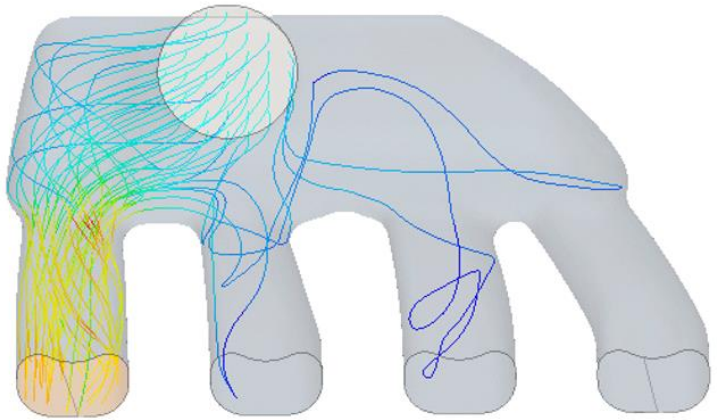
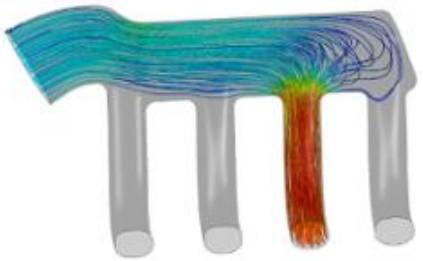


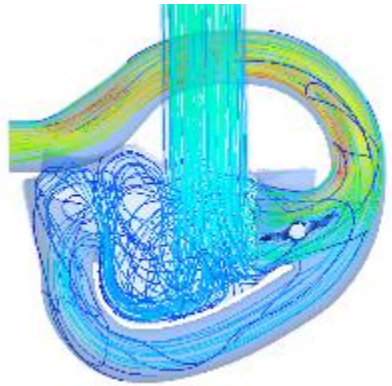


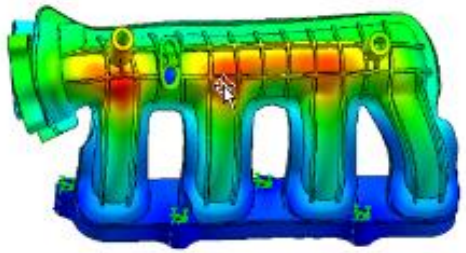
CAE/CFD在发动机进气歧管中的应用

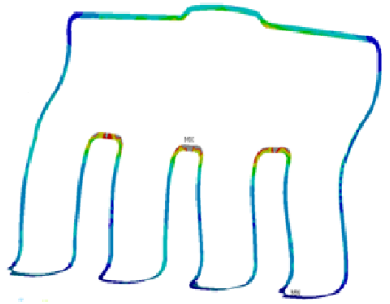
进气歧管所需 CAE/ CFD分析

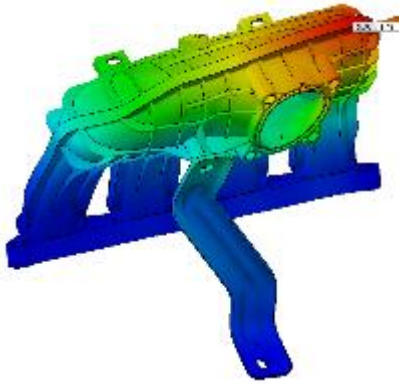
- 气道CFD分析，评估进气均衡性
- 爆破压力分析，确保通过压力测试
- NVH分析：模态，频响，随机振动，噪声
- 振动应力分析：避免歧管和支架断裂
- 模流分析Moldflow：推荐浇口位置，优化工艺参数；保证焊接和装配
- 设计难点：气道长度要求，形状复杂，如焊接分片，避让安装螺孔

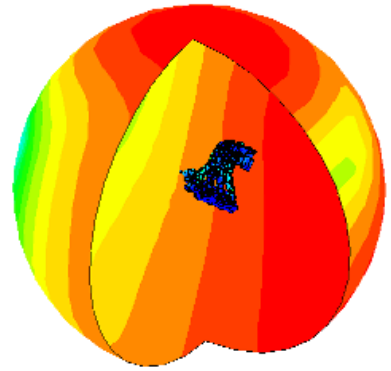


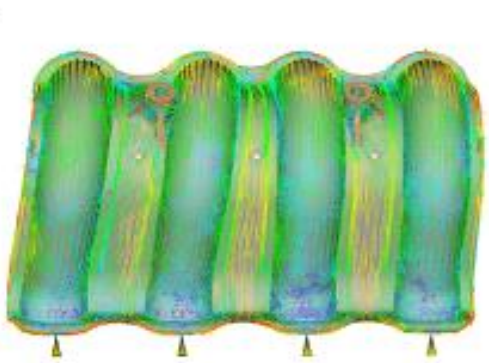




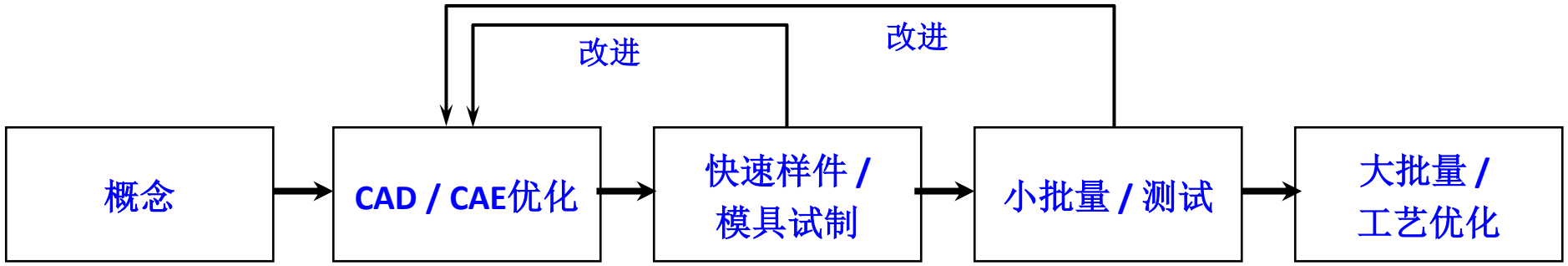








进气歧管开发流程



- 发动机排量
- 发动机参数
- 设计空间
- 设计目标
- 材料选择
- 工艺确认
- 焊接分片
- 可行性
- 风险评估

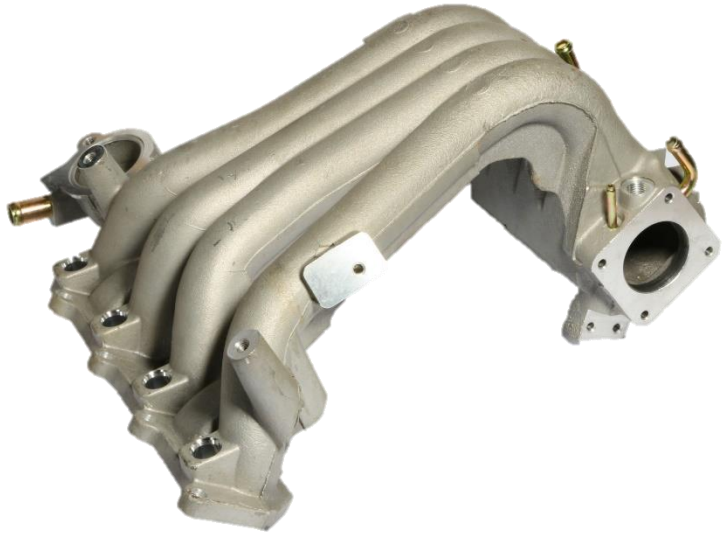
- 气道CFD分析
- 爆破压力
- NVH
- 模流分析Moldflow
- 密封性能
- 3D建模
- 方案优化

- 快速样件测试
- 气道验证
- 装配干涉检查
- 模具设计
- 浇口选定
- 流道，冷却系统
- 翘曲变形
- 焊接准备

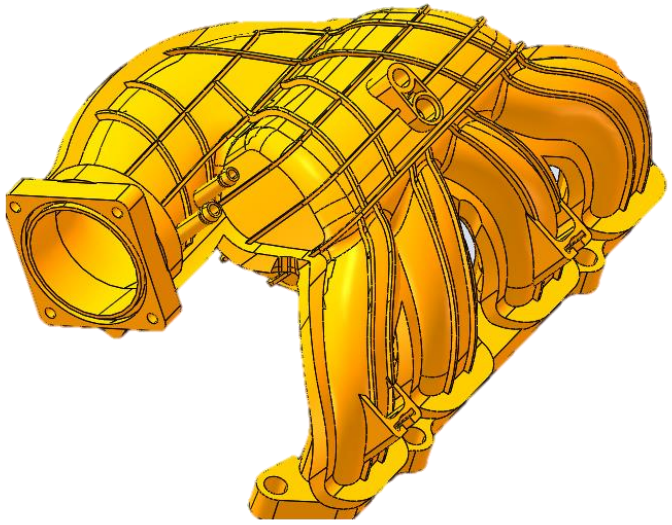
- 性能评估
- 爆破：动态和静态
- 耐久性
- NVH
- 气密性
- 热老化，热冲击
- 嵌件测试
- 型试
- 台架试验
- 整车性能

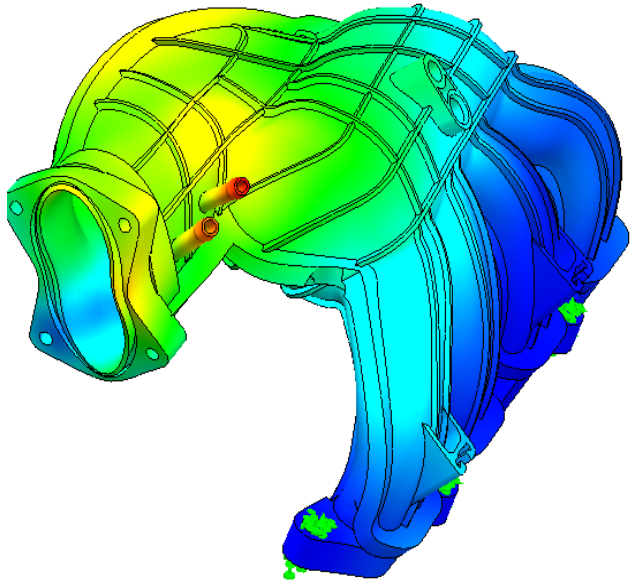
- 机器选择
- 模具改进
- 注塑优化
- 焊接工艺优化

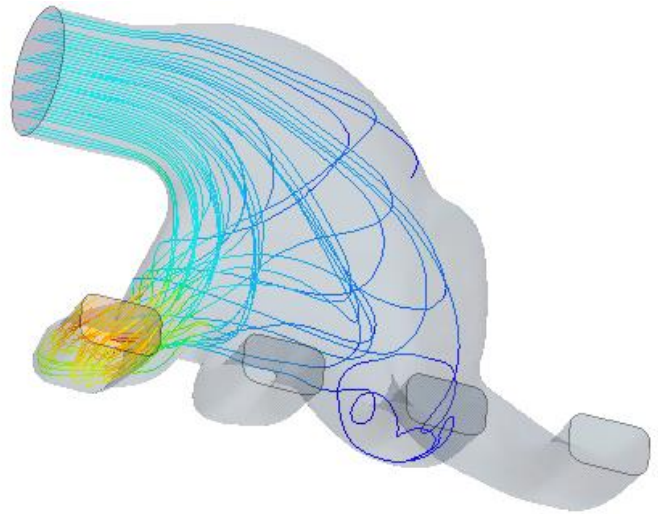
塑料进气歧管的发展



- 铝改塑，轻量化
- 振动摩擦焊接
- 降低成本，提高生产效率
- 自然吸气到涡轮增压







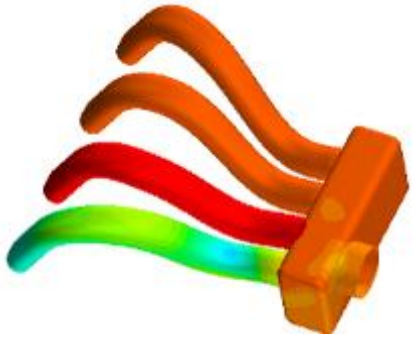
自然吸气与涡轮增压进气歧管

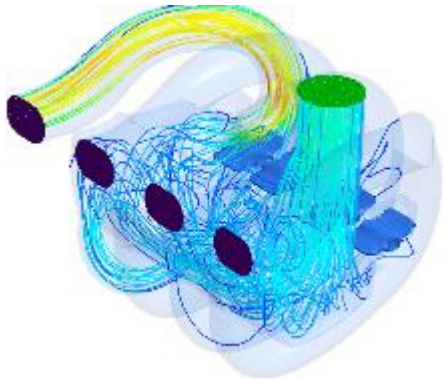
- 管子很长，进气共振技术
- 管子尺寸通过1D软件来计算
- 高速性能受限，结构复杂

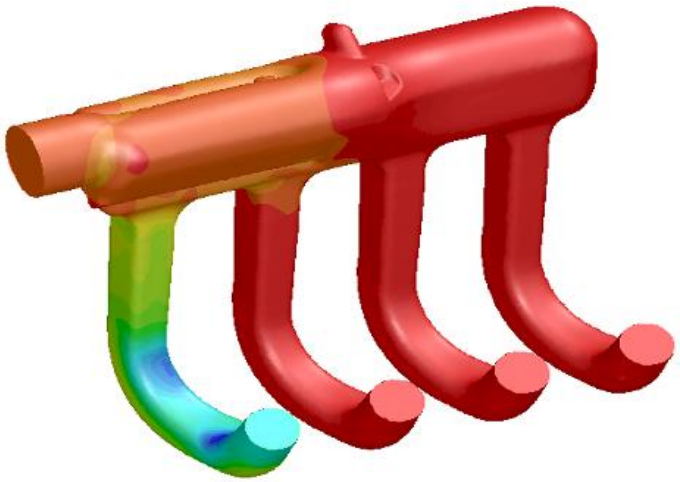
- 管子短，适合于高速工况
- 通过涡轮增压来增加进气量
- 系统复杂，温度高

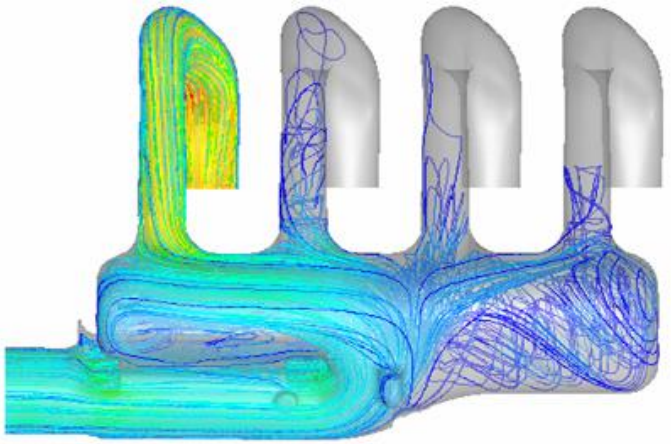
气道CFD：稳态与瞬态（非定常）

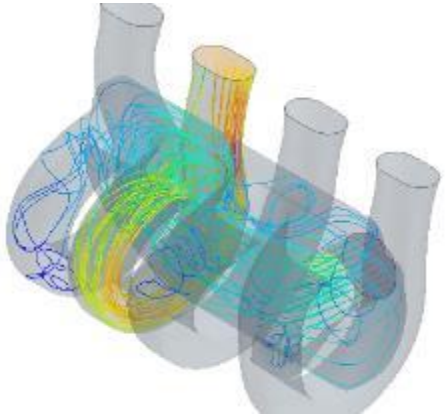
- 评估进气均衡性
- 流场分布，流速计算







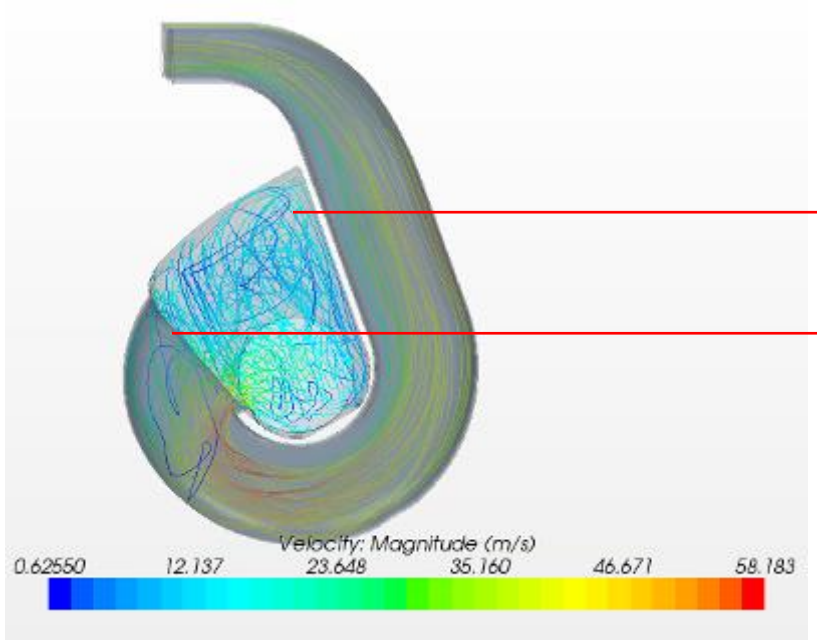


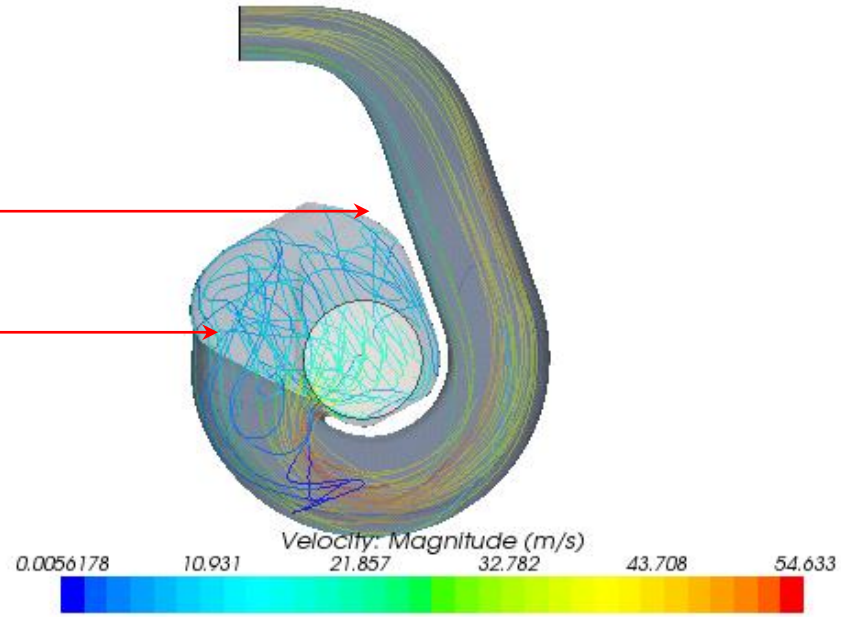


6

稳压腔优化

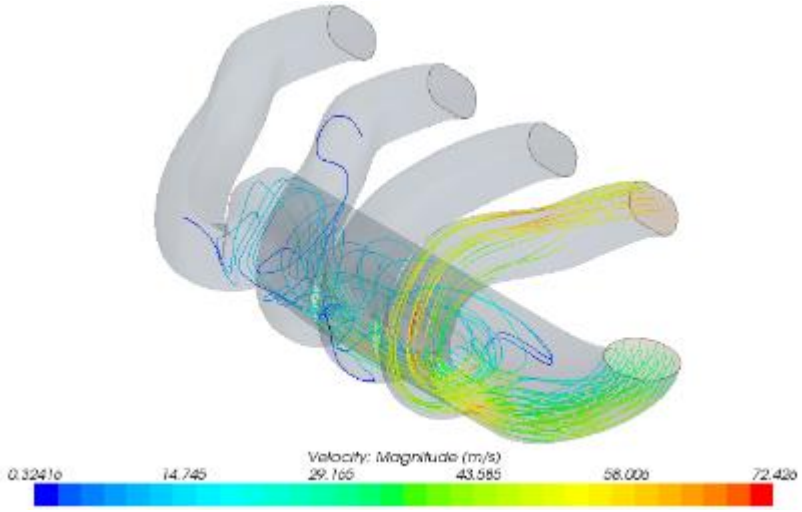
经过CFD优化后，压力损失平均降低约15%，进气均衡性提高（各缸差异仅2%）



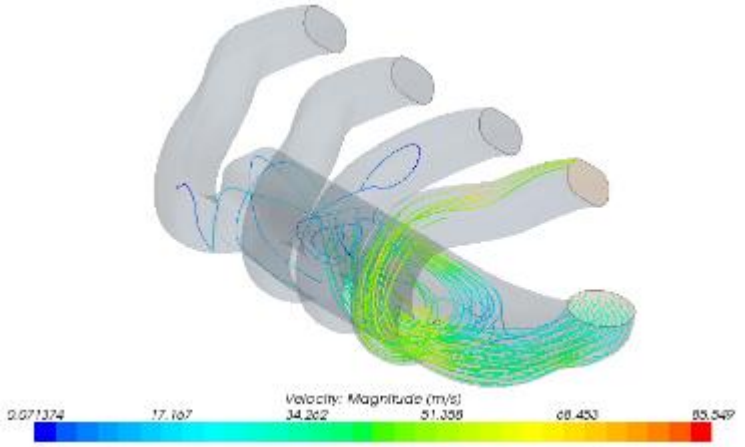


压力损失(Pa)	Outlet 1	Outlet 2	Outlet 3	Outlet 4
原方案	1320	1356	1429	1214
改进后	1109	1142	1142	1129

气道优化



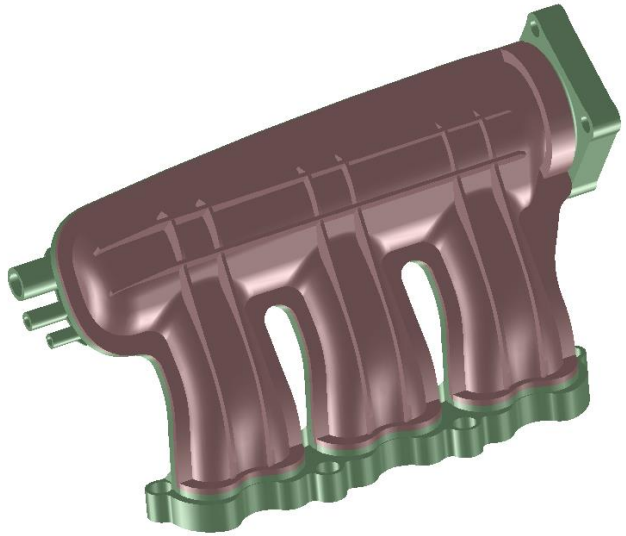
方案1，最大流速：72 m/s

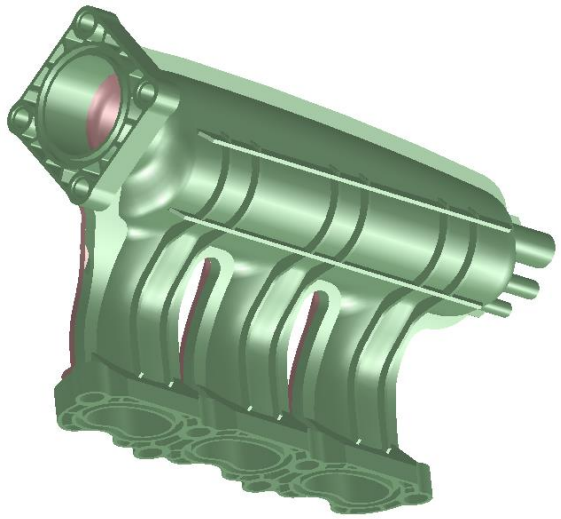


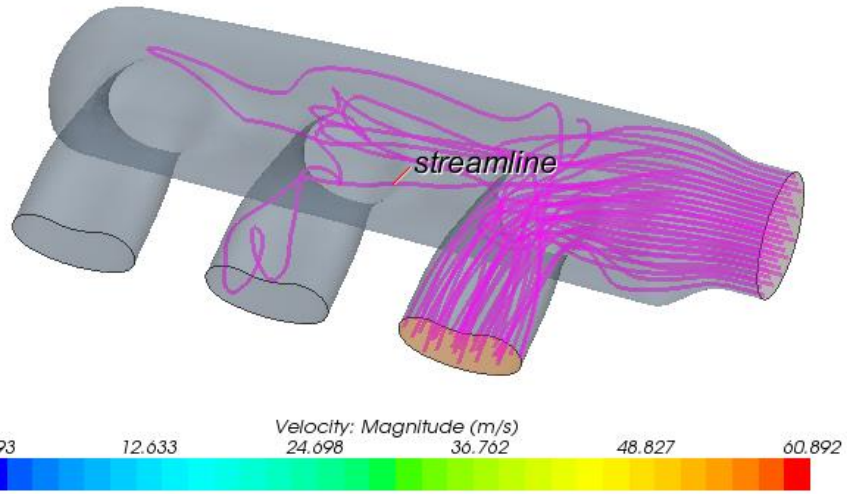
方案2，最大流速：85 m/s

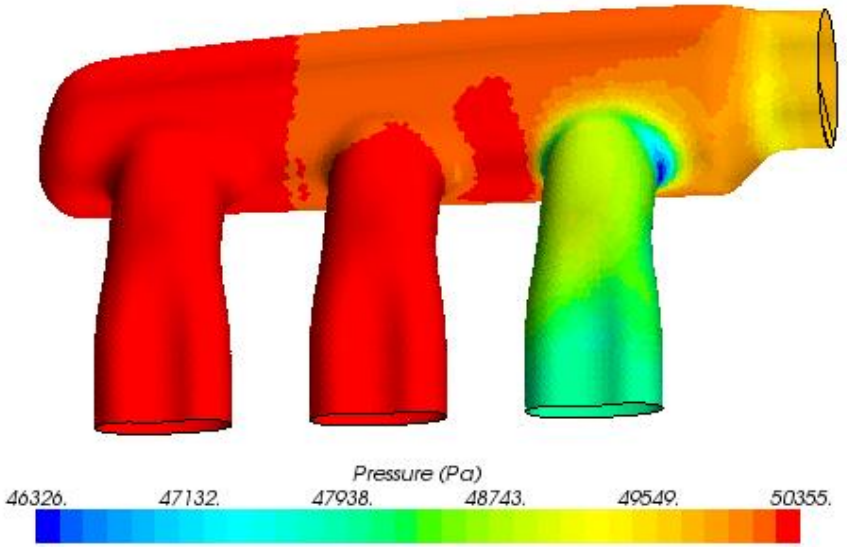
8

涡轮增压进气歧管





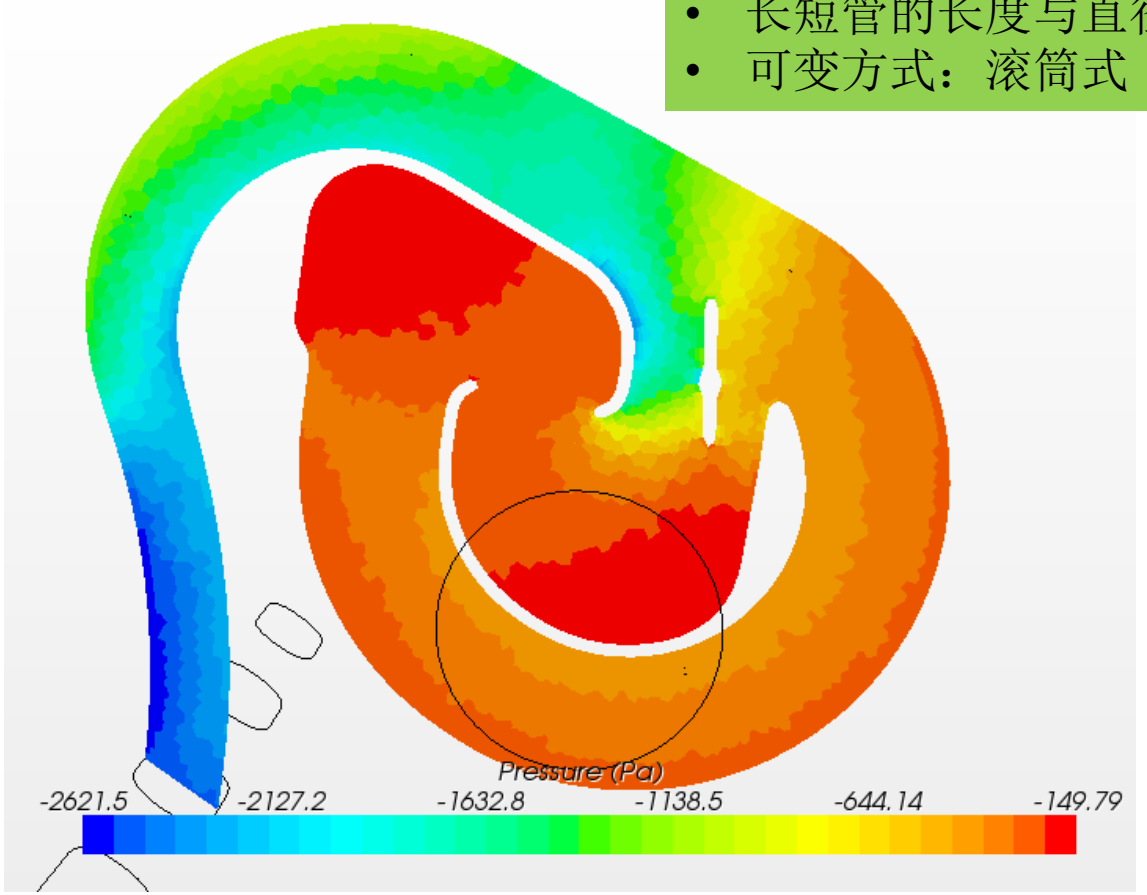

streamline
Velocity: Magnitude (m/s)
0.56793
12.633
24.698
36.762
48.827
60.892

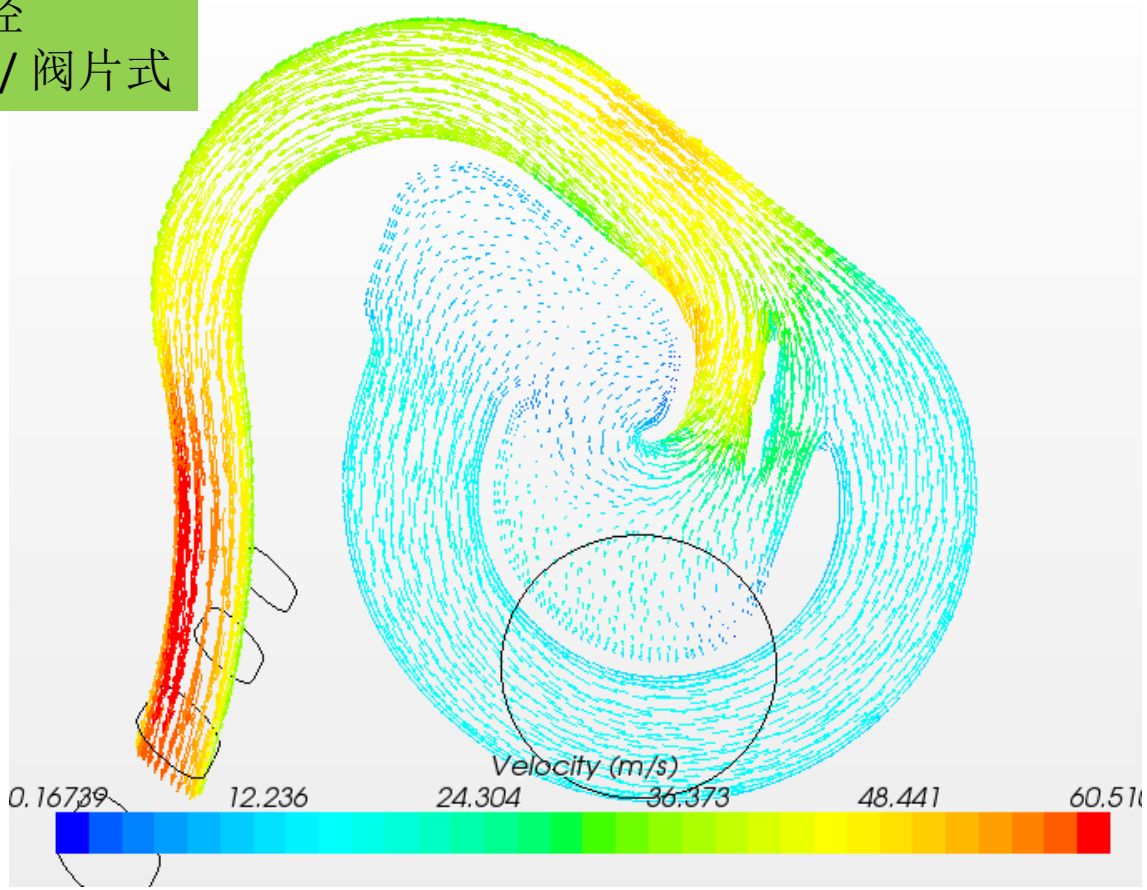

Pressure (Pa)
46326.
47132.
47938.
48743.
49549.
50355.

9

可变长度进气歧管

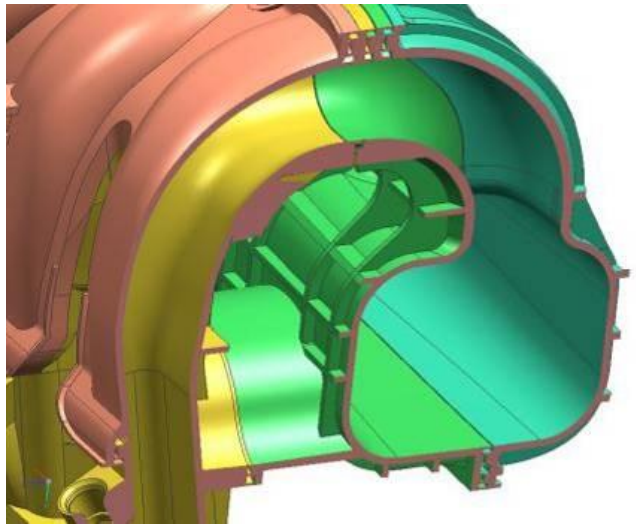
- 长气道有利于提升低速扭矩
- 短气道有利于提升高速功率
- 长短管的长度与直径
- 可变方式：滚筒式 / 阀片式

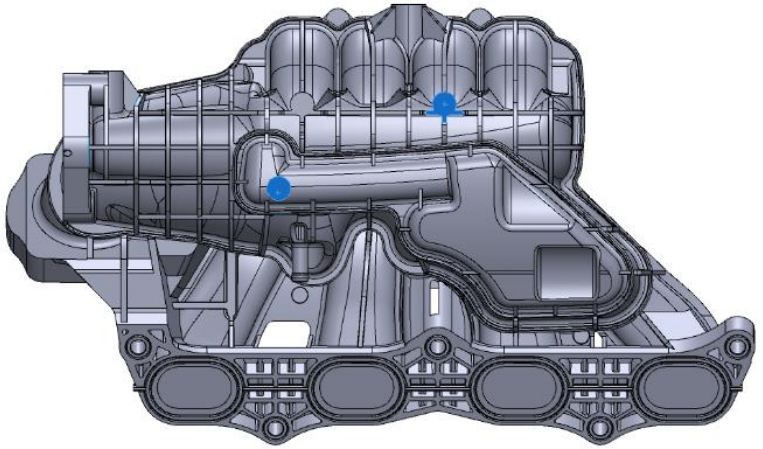


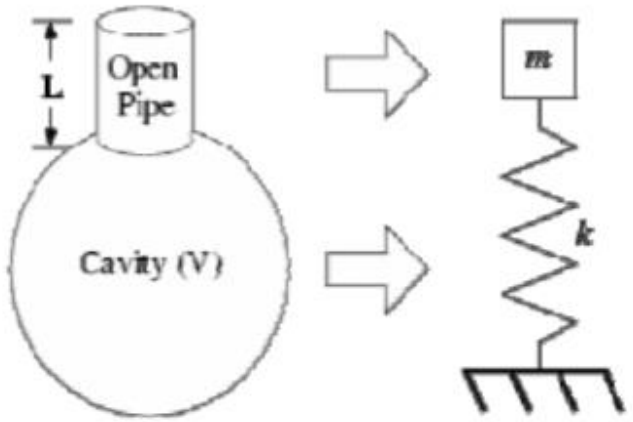


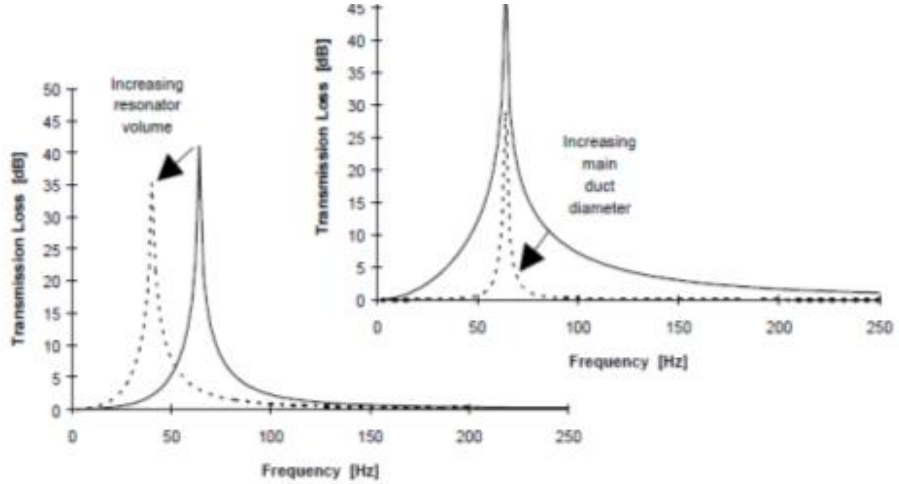
Helmholz 共鸣箱设计方案

设计参数：
- 空腔容量
- 颈口尺寸，位置
- 共振频率







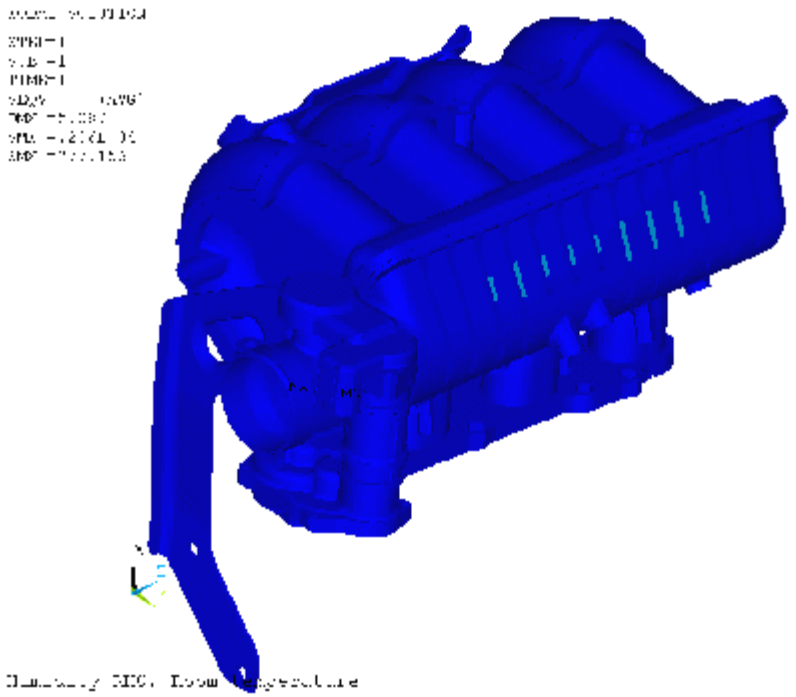


$$\text{Resonant frequency} = f_r = \frac{C}{2p}\sqrt{\frac{S_b}{V L_b'}}$$

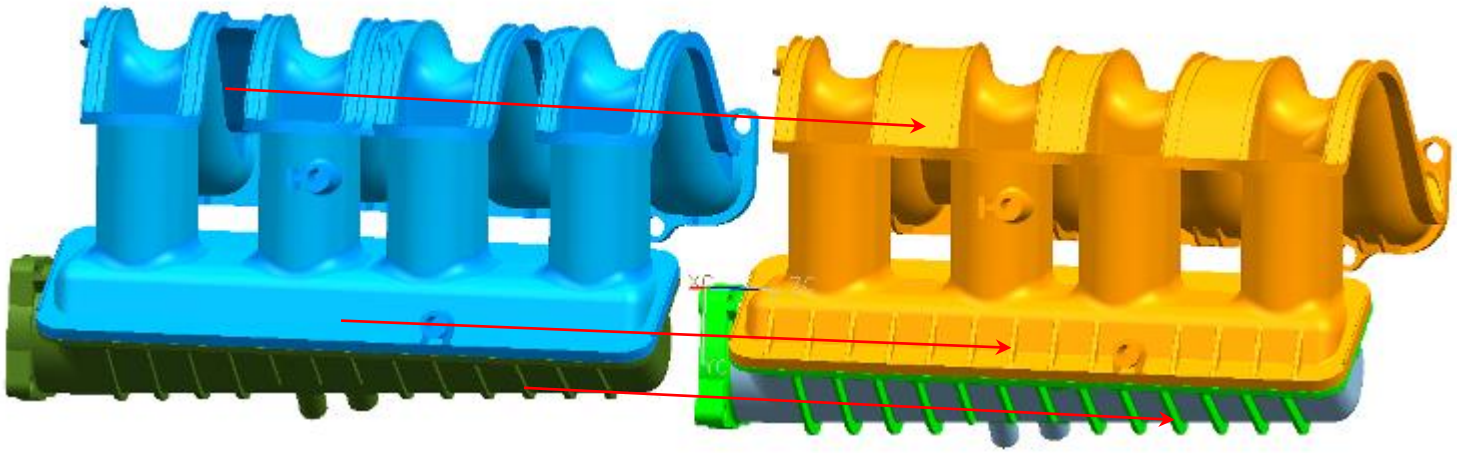
11

爆破压力：发动机回火状态，要能承受一定的压力

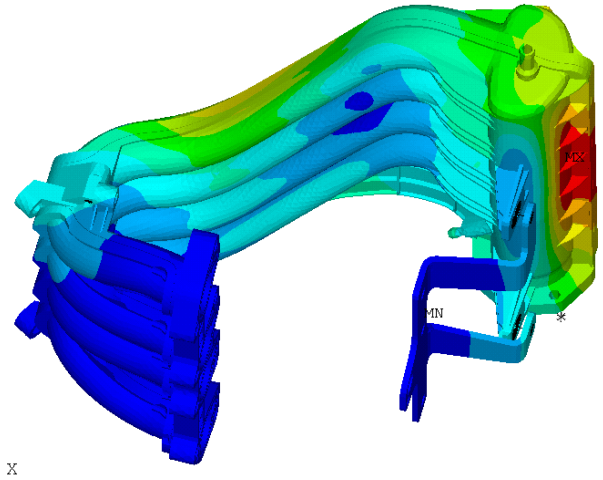
塑料歧管爆炸事件时有发生

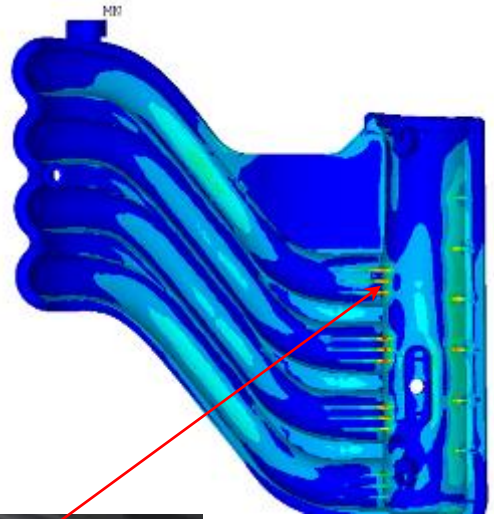


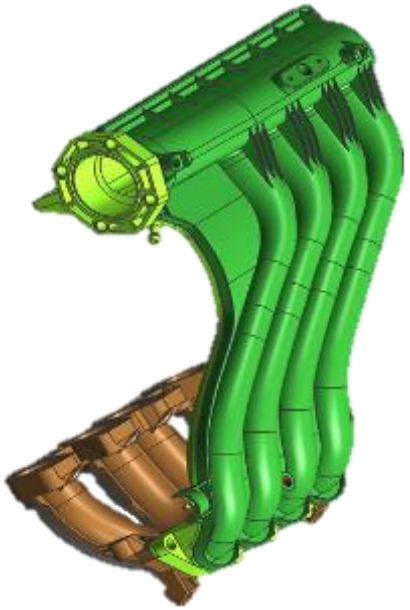
结构优化：稳压腔加强筋



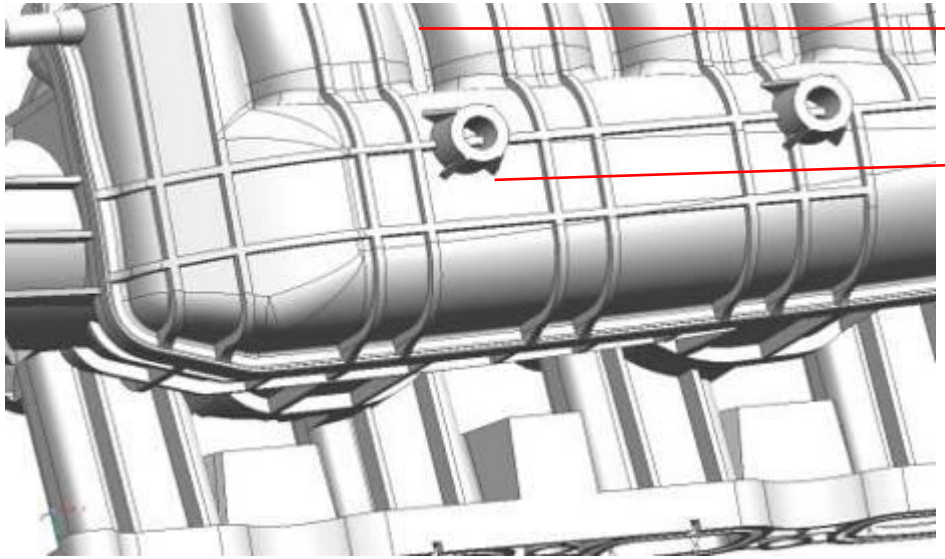
爆破压力分析

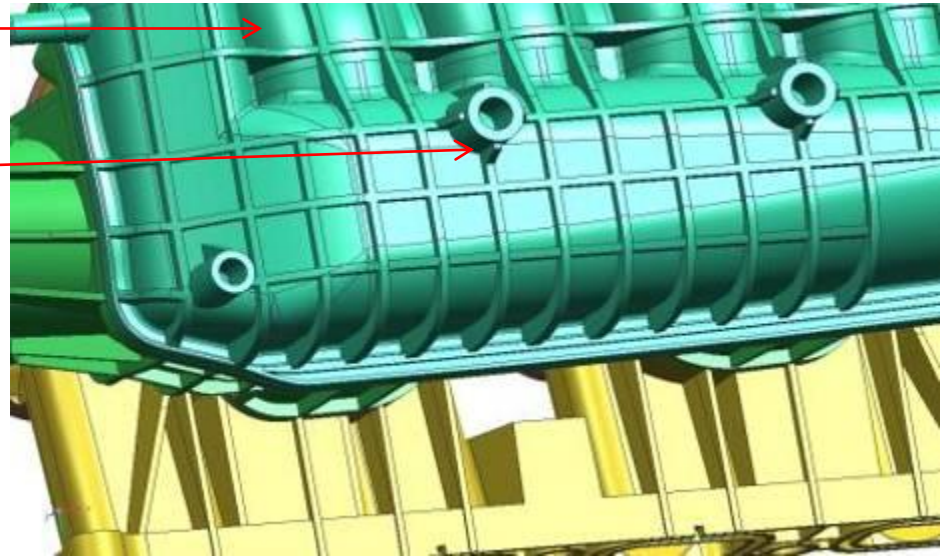






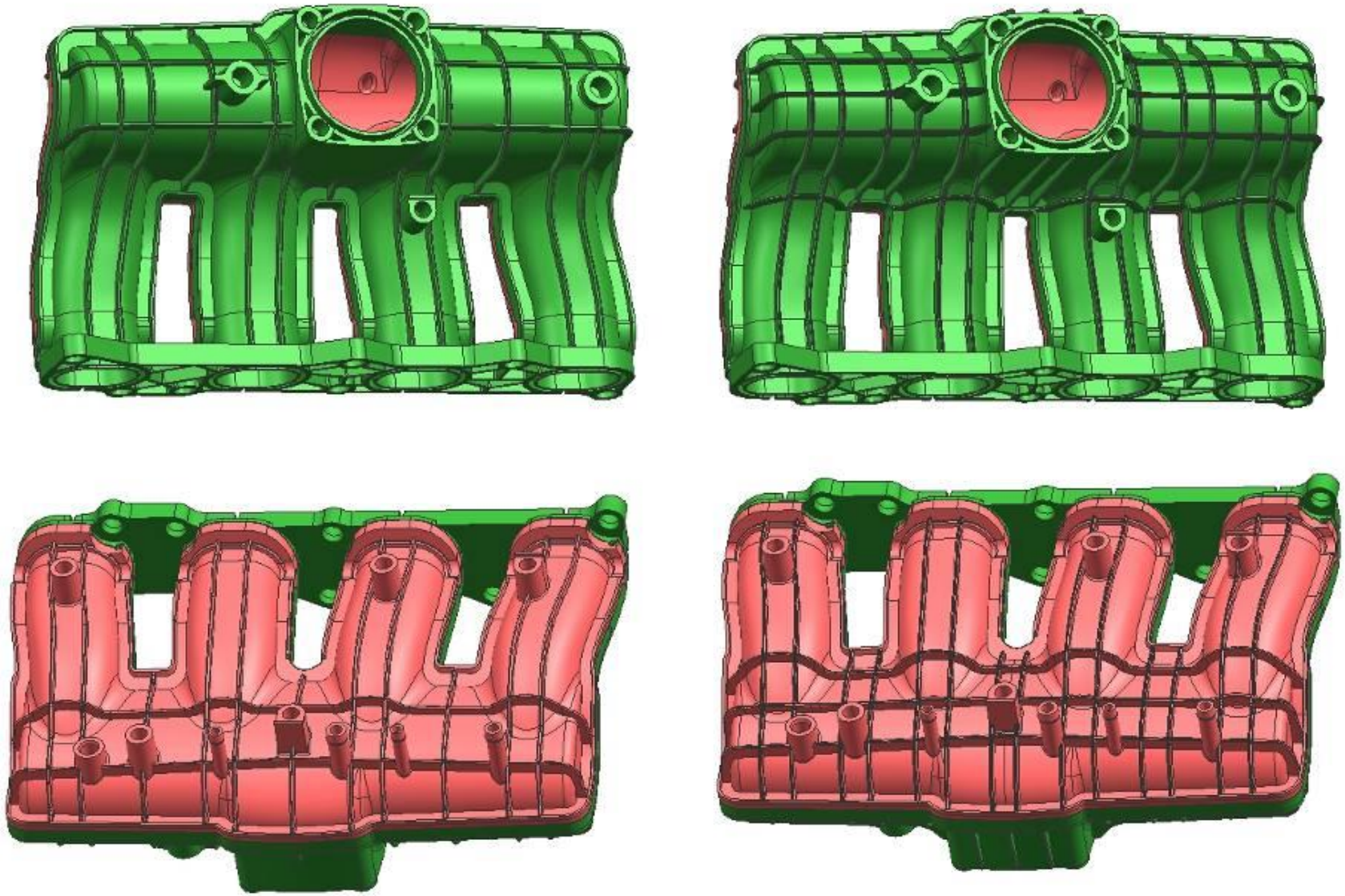
结构优化



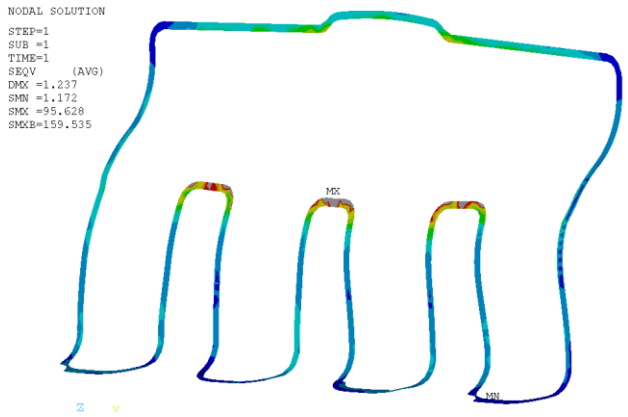


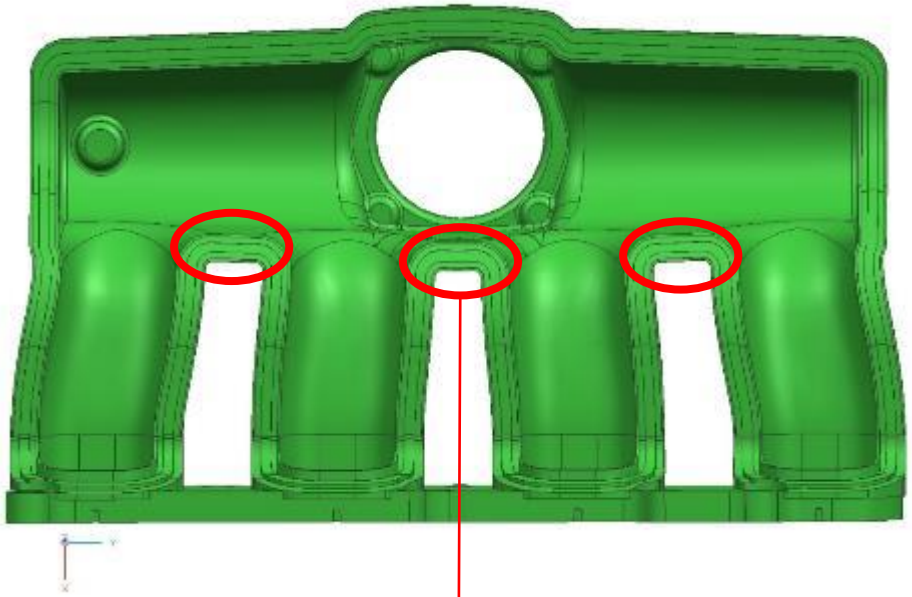
- 结构复杂，光凭经验很难找出薄弱区域，无法定量判断
- 提出方案时需要综合考虑各种因素，如模具可行性，注塑和焊接工艺可行性，翘曲变形，装配等

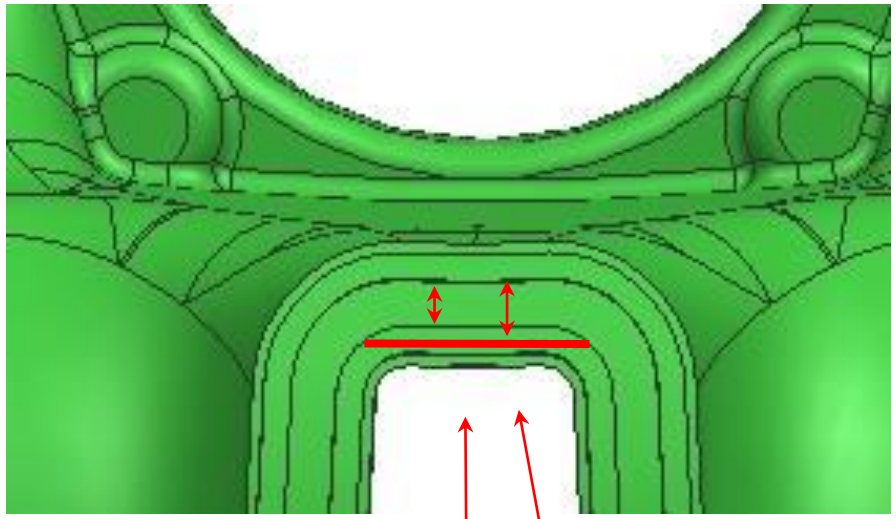
结构优化



焊接筋优化







Increase weld bead width from 4mm to 4.5 or 5 mm

摘要

CAE/CFD 发动机塑料进气歧管，可变气道，进气均衡性，功率扭矩，爆破压力，空滤模块，中冷器，支架，振动摩擦焊接，橡胶密封压力，玻纤取向，NVH模态，频响，PSD随机振动，噪声，刚度，疲劳，冲击。模流，注塑工艺，浇口。铝改塑，涉及软件 Ansys workbench, Fluent,CFX, Moldflow, Marc。

- 基于作者的经验以及认知水平，仅供参考。如果与您产品的CAE分析方法有所不同，请以试验为准！

- 培训或项目开发需要，请与我司联系。